Development of a Digital Integrated and Minimized Public Address System with Central Control

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Abstract

There are two kinds of public address (PA) systems: analog PA systems and digital PA systems. The digital PA systems have better communication quality than analog PA systems, and many companies manufacture various types of digital PA systems. Digital PA systems are used in public places where there are vast crowds of people. In this paper, a digital, minimized, and integrated PA system was developed. Its facilities included an external input, a microphone, a CD, and a radio for a PA system. The developed digital integrated PA system with an operational MICOM will make it possible to centrally control digital device facilities. The operational MICOM has three layers: a control layer, a processing layer, and a user interface layer. In addition that, the remote control and key inputs are used for the central control. The execution results showed that the system can operate different digital media individually or together concurrently.

Keywords: *digital integrated public address; remote control; operational MICOM; external input; central control*

1. Introduction

A public address system (PA system) is an electronic amplification system with a mixer, amplifier and loudspeakers, used to reinforce a sound source, e.g., a person giving a speech or a DJ playing prerecorded music, and distributing the sound throughout a venue or building. Simple PA systems are often used in small venues such as school auditoriums, churches, and small bars. PA systems with a large number of speakers are widely used in institutional and commercial buildings, to read announcements or declare states of emergency. Intercom systems, which are often used in schools, also have microphones in each room so that the occupants can reply to the central office. Sound reinforcement systems and PA systems may use some similar components, but with differing applications. Sound reinforcement systems are for live music or performance, where PA systems are for reproduction of speech and recorded music in buildings and institutions. PA systems typically consist of input sources, preamplifiers and/or signal routers, amplifiers, control and monitoring equipment, and loudspeakers. Input sources refer to the microphones and CD players that provide sound input for the system. These input sources are fed into the preamplifiers and signal routers that determine the zones to which the audio signal is fed. The preamplified signals are then passed into the amplifiers. Depending on a country's regulations these amplifiers will amplify the audio signals to 50V, 70V or 100V speaker line levels. Control equipment monitors the amplifiers and speaker line for faults before it reaches the loudspeakers. This control equipment is also used for separating zones in a PA system. The loudspeaker is used as a transducer, turning electrical signals into analog sound signals [1].

There are two kinds of PA systems, which are an analog PA system and a digital PA system. The digital PA system has more communication quality than the analog PA, and there are a variety of digital PA systems made by many companies. A Digital PA system is utilized in all public places attended by vast crowds of people. In daily operation, such systems are not only used for public information or for promotional advertising, but also for musical entertainment or for internal purposes like the communication among staff in widespread buildings (by live announcements or by intercom operation). In cases of emergency, such systems become particularly important: reliable alarming and acoustical guidance of crowds with people being directed to certain targets is absolutely necessary for the prevention of chaos and panic, so that organization of a scheduled evacuation can proceed as planned.

Notably, the Korean government has strengthened the Fire Services Act of 2010, which requires most buildings to have a PA system facility for emergencies or announcements. Due to this regulation, a low-cost yet good-quality digital PA system is required in the PA market. Also, consumers who have an analog PA system now want to change it into a digital PA system. Moreover, a digital PA system can be easily installed in a building PA system in place of the existing PA system. The digital components of a digital PA system are composed, however, of individual digital devices. They are not integrated on a DSP board. They are merely a set of digital devices composed of a CD, radio, MP3 player, etc. The structure of a PA system also makes it difficult to operate. Moreover, a PA system costs much because all the components must be bought. Finally, a PA system is big so it requires much space for its installation in a building.

In this paper, a digital, minimized, and integrated PA system with central control using remote control was developed. This PA system integrated digital components that included a CD, radio, and MP3 player on a DSP board. Moreover, both the size of the PA system and the size of the space for its installation were decreased. The cost of the PA system was also drastically reduced and its installation eased. In an analog PA system facility, the connector can just be pulled out and plugged. as Also, the operator can operate the PA system centrally using remote control. The central control function can provide an easy and convenient method of operating the PA system because the operator has much user experience with remote control devices, through other devices. To provide the central control, an operational MICOM was made. It is composed of three layers: a control layer, a processing layer, and a user interface layer. In addition, the key inputs were used for the central control. The execution results showed that the system can operate different digital media individually or together.

The structure of this paper is as follows. Section 2 briefly introduces related studies. Section 3 describes the digital integrated PA system, and Section 4 presents its implementation details. Finally, the conclusions are drawn and the future study is discussed in Section 5

2. Related Works

2.1. Digital PA System: Praesido

Praesideo is a fully digital public address system that meets all the requirements placed by professional users on a public address/emergency system. The system brings highly innovative and advanced digital technology to the public address market. The processing and communication of both audio signals and control data entirely in the digital domain makes the system superior to other currently available public address and emergency sound systems. Digital signal processing allows significant improvements in the audio quality achieved. The Praesideo system is designed for configuration from a PC, which makes installation and setting of operating parameters

very simple and user-friendly. All audio processing is performed in the digital domain. Communication between the units is via plastic fiber or glass fiber cabling, depending on the distance between the units. The cabling uses the daisy chain principle. This makes the cabling and installation very quick, simple and easy. The system cabling is a closed loop, which allows redundancy to be achieved. The system is supplied with user-friendly software for system configuration. This allows all system functions to be configured. The software is based on web technology, which gives authorized users full freedom of configuration in terms of time and location. The simplified and accurate organization of the programming features makes navigation highly user-friendly and fault-tolerant. The software also provides clear indication of any parameters, which have not been programmed before exiting from any stage of the configuration process. The system architecture is based on daisy-chaining the units. It is possible to add or remove equipment anywhere in the network without affecting the performance of other units, provided that a network connection is available. This makes the system easily expandable by the customer, without adding any additional electronics at the network controller unit. Thanks to this network architecture, users can start with a small system in the initial stage and expand the system later simply by adding the required new units to the existing network. The system can also be configured for redundant cabling using a ring cabling structure [2].

2.2. M16C/60, M16C/20, M16C/Tiny Series

NC30 is the C compiler for the Renesas M16C/60, M16C/30, M16C/Tiny, M16C/20, M16C/10, R8C/Tiny series. NC30 converts programs written in C into assembly language source files for the M16C/60, M16C/30, M16C/Tiny, M16C/20, M16C/10, R8C/Tiny series. NC30 consists of the following eight executable files: nc30, cpp30, ccom30, aopt30, sbauto, StkViewer & stk, utl30, and MapViewer. By specifying options, NC30 can perform the series of operations from compiling to linking. You can also specify for the as30 relocatable macro assembler and four for the ln30 linkage editor by including the –as30 and –ln30 command line options when you start NC30. cpp30 is the executable file for the preprocessor. cpp30 processes macros starting with # (#define, #include, etc.) and performs conditional compiling (#if-#elseif-#endif, etc.) ccom30 is the executable file of the compiler itself. C source programs processed by cpp30 are converted to assembly language source programs that can be processed by AS30. Apot30 is the assembler optimizer. It optimizes the assembler codes output by ccom30. Sbauto analyzes the number of times external variables are referenced in a function based on the inspector information that was output by the compiler, and outputs optimum SB relative. StkViewer is the executable file for the utility that graphically shows the stack size and the relationship of function calls needed for program operation. Also, stk is the execution file for the utility that analyzes the information required for StkViewer. StkViewer calls stk to process the Inspector information added to the absolute module file (.x30), find the stack size and the relationship of function calls needed for program operation, and displays the result. Also, by specifying information, if any, that could not be fully analyzed with only the Inspector information, StkViewer recalculates the stack size and the relationship of function calls and displays the result. To use StkViewer & stk, specify the compile driver startup option –finfo when compiling, so that the Inspector information will be added to the absolute module file (.x30). utl30 is the execution file for the SBDATA declaration utility and SPECIAL page Function declaration Utility. By processing the absolute module file (.x30), utl30 generates a file that contains SBDATA declarations (located in the SB area beginning with the most frequently used one). To use utl30, specify the compile driver startup option –finfo when compiling, so that the absolute module file

(.x30) will be generated. MapViewer is the execution file for the map viewer. By processing the absolute module file (.x30), MapViewer graphically shows a post-link memory mapping. To use MapViewer, specify the compile diver startup option –finfo when compiling, so that the absolute module file (,x30) will be generated [3, 4].

3. Development of the Digital Integrated Public Address System

Figure 1 shows the structure of the digital integrated PA system. The range of equipment of the system has multiple functions combined in a single unit. This feature drastically reduces the number of equipment used in the system. This makes the overall system highly cost-effective.

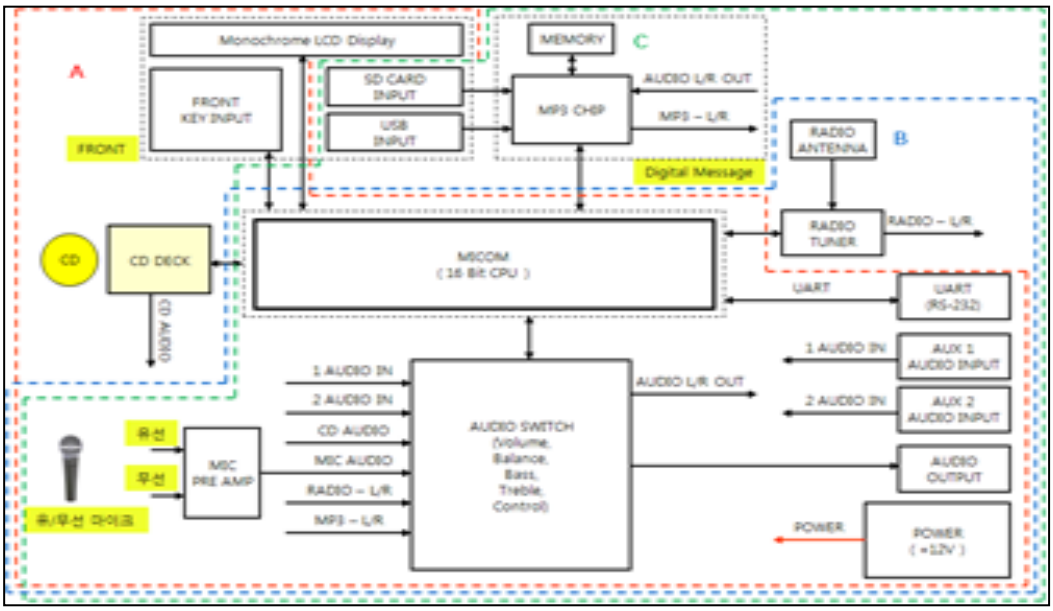

Figure 1. System Structure

As Figure 1 shows, the digital PA system has many functions, which include external inputs, broadcasting, and an operational MICOM for central control. Such functions and their roles are described as follows.

1) Digital processing and digital amplifier

The full digital amplifier enables lower overall weight, power consumption, and temperature rise during the system operation.

2) Operational MICOM

The operational MICOM has three layers: a control layer, a processing layer, and a user interface layer. The control layer controls the devices, which are the audio switch controller, MIC controller, MP3 controller, radio tuner controller, and CD player controller. The processing layer edits sounds and messages and processes the control signal and status information of devices. The user interface layer is for user interface. The development of a digital PA system with an operational MICOM will make it possible to centrally control the digital device facilities. In addition, the remote control and key inputs are used for the central control.

Figure 2 shows the structure of the operational MICOM.

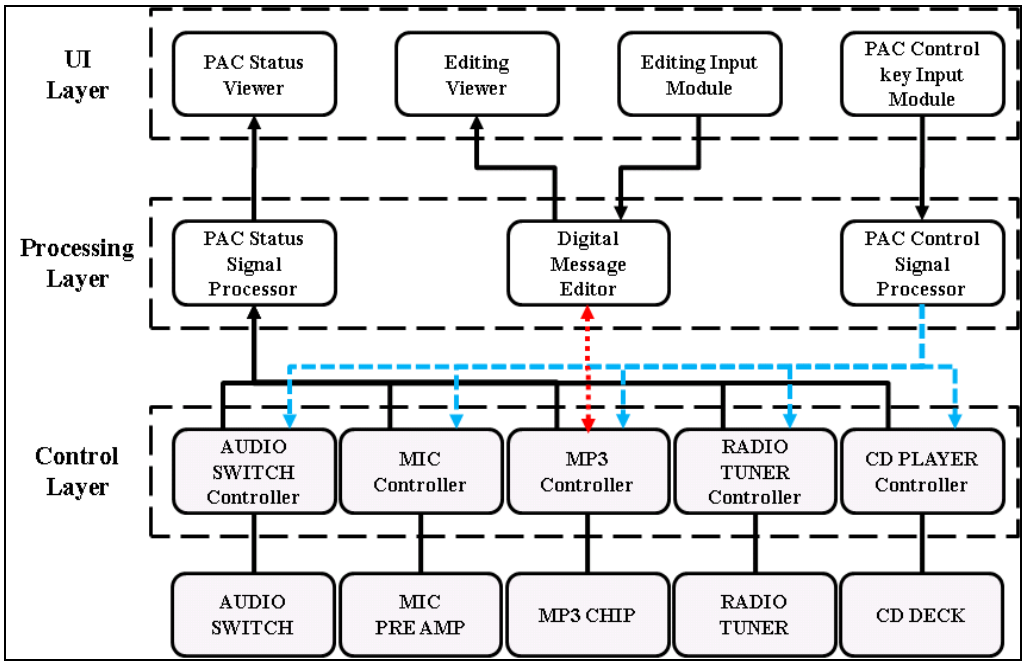

Figure 1. Operational MICOM Layers

3) Front Panel of PA System

- POWER SWITCH: This is the button to turn on or off the power. If turning on this switch, display lights on and the unit starts to operate. If turning off the switch, the unit becomes standby status. If you want to turn on the system, you must press this button long (about 2 seconds).
- DISPLAY WINDOW: This is a window to display system information of the operation. If the system is operating the CD player then it displays CD track name and time for the music currently played.
- USB TERMINAL: This is a terminal to connect USB memory. Copying a CD to USB, saving files from the internal memory to USB or recording a broadcasting to USB or internal memory is available. Music files saved in memory can be played directly using USB function.
- TONE CONTROL VOLUME: This is a volume to control tone of signal. You can adjust each frequency band such as 200Hz/500Hz/1.2Khz/3Khz/8KHz. Select the relevant frequency with the tone button and control volume with the volume button.
- INPUT SELECT (FUNCTION) BUTTON: This is a button to select input signal and you can select one of FM TUNER, CD, USB, AUX, or DIGITAL INPUT.
- EJECT: This button is used to take out a disc using UART.
- MODE SELECT BUTTON: If pressing this button once, you can check setting status of the current mode. Whenever you press the button, the mode changes in order of radio -> CD-> USB. After adjusting the tone, press the button long (about 2 seconds), then the setting is saved in the relevant mode.

- SPEAKER SELECT BUTTON: There is speaker selection button. It is convenient to broadcast to some selective areas or to all areas.
- VOLUME: This is a volume to control of the TUNER/CD/USB/AUX/DIGITAL input.
- RECORD & ERASE BUTTON: This is a button used for broadcasting or recording contents of lecture which are saved in the relevant memory as MP3 file.
- DISC INSERT SLOT: This is the insert slot of a Disc. If you put a Disc in the slot, then the disk is automatically entered into the slot.
- CD/ USB/ RADIO FUNCTION BUTTON: The button available lights depending on function selected.
    - PLAY BUTTON: This is a button to playback
    - STOP BUTTON: This is a button to stop playing.
    - SEARCH DOWN/UP BUTTON: This is a button to move forward or backward from a track during play a disc. Keep pressing this button to find the position you want to play.
    - PAUSE BUTTON: This is a button to pause playback.
    - SKIP DOWN/UP BUTTON: This is a button to search for music before or after the music played.
    - RANDOM BUTTON: This button is used when playing songs in a disc randomly.
    - REPEAT BUTTON: This button is used to playback music in Repeat Mode.

4. Implementation and Results

A digital PA system was implemented with the design presented in the previous section, using C. This PA system integrated the following digital components on a DSP board: a CD, radio, and MP3 player. The MCU that was used in this PA system is the Renesas M16C/60, M16C/30, M16C/Tiny, M16C/20, M16C/10, and R8C/Tiny series. It is single-chip microcomputer developed for built-in applications where the microcomputer is built into applications equipment. The MCU supports instructions suitable for the C language with frequently used instructions arranged in one-byte op-code. Therefore, it allows you for efficient program development with few memory capacity regardless of whether you are using the assembly language or C language. Furthermore, some instructions can be executed in clock cycle, making fast arithmetic processing possible. NC30 is the C compiler for the Renesas M16C/60, M16C/30, M16C/Tiny, M16C/20, M16C/10, R8C/Tiny series. NC30 converts programs written in C into assembly language source files for the M16C/60, M16C/30, M16C/Tiny, M16C/20, M16C/10, R8C/Tiny series. Moreover, various communication methods were used to implement this system. The i2c was used to communicate between EEPROM and audio. The UART (Universal Asynchronous Receiver/Transmitter) method was used to communicate from the MCU to the CD-ROM, Debug, and MP3 chip, and vice versa [5, 6]. In addition, internal interrupts (timer, analog/digital converter, and IR sensor) were used. A remote control with a NEC format [7] was used. As Figure 3 shows the digital components that were integrated on a DSP board.

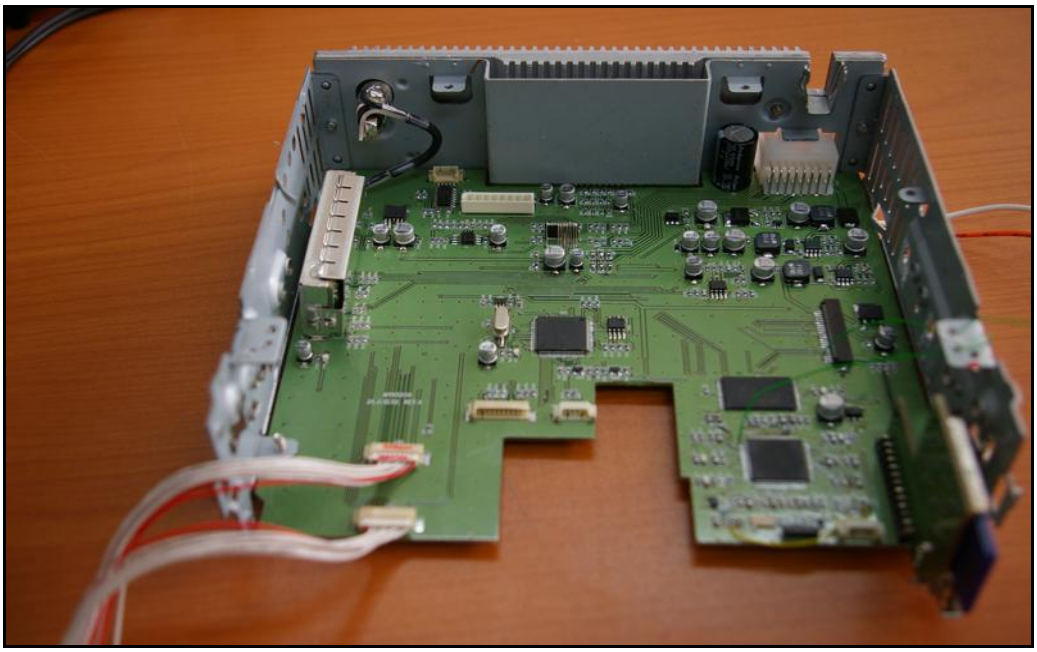

Figure 2. Integrated System on a Board

Figure 4 shows the display window. This window displays the system's operating information. If the system is operating the CD player, the display window shows the CD track name and time for the music being played. Also, if the radio is on, the display window shows the radio frequency information and the radio band (FM or AM). As Figure 4 shows, the display shows that the radio of the digital PA system is running, the radio band is FM, and the frequency is 87.5 MHz.

Figure 3. Display Window

Figure 5 shows the front panel of the developed digital PA system, which has the following digital components: a CD, radio, MP3, external input, etc. Accordingly, the system could provide the facilities needed to control or operate these devices. As presented in Section III, the front panel has many buttons and input keys. It has a power switch, a display window, a USB terminal, a tone control volume panel, an input select button, an eject button, a mode select button, a speaker select button, a volume controller, a record-and-erase button, a disc insertion slot, a radio/CD/USB function button, etc. The buttons are not enough, however, to control the functions individually, and should operate in the toggle mode. For example, whenever the mode select button is pressed, the mode changes in the following order: radio -> CD -> USB.

Figure 5. Front Panel

5. Conclusions and Future Work

Notably, the Korean government has strengthened the Fire Services Act of 2010 and most buildings must have a PA system facility in case of an emergency or announcement. However, the digital components of digital PA system are composed of each digital devices individually. They are not integrated on a DSP board. They are just a collection set of digital devices which are cd, radio, MP3 player, and etc. In this paper, a digital, minimized, and integrated PA system was developed. It has the following facilities: an external input, a microphone, a CD, and a radio for a PA system. This developed digital integrated PA system with an operational MICOM will make it possible to centrally control digital device facilities. The operational MICOM has three layers: a control layer, a processing layer, and a user interface layer. In addition, the remote control and key inputs were used for the central control. The execution results showed that the integrated digital PA system can operate digital media individually or together. The performance and functions of Praesideo and the developed PA system were compared. The performance and function of Praesideo were better than those of the developed integrated digital PA system, but the size and cost of the developed PA system are more reasonable.

In the future study, another function will be given to the developed digital PA system that will operate as follows: while in the dark in an emergency, one can move according to an escape path by listening to sounds using the intelligent digital PA system.

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